The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

FEBRUARY, 1886.

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By faith we understand that the worlds have been framed by the word of God, so that which is seen hath not been made out of things which do appear.

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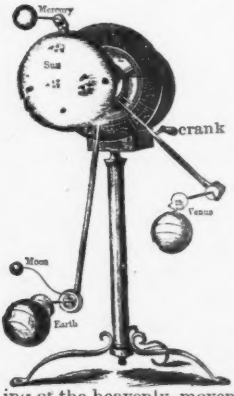

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When the Earth's axis is pointed to the north, it will continue so pointing throughout the revolution, and will be in the Ecliptic. The Earth rolls over from west to east, and if the Equator be continued to the sky, it will meet the Equinoctial. So with the Ecliptic, if continued, it will come near to the Moon, near to Mercury, near to Venus, and always to the Sun.

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XUM

The Sidereal Messenger

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory, Northfield, Minnesota.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 5. No. 2. FEBRUARY, 1886. WHOLE No. 42.

TO COMPUTE THE ELEMENTS OF METEORIC ORBITS

S. J. CORRIGAN. *

[For the Messenger.]

So far as the writer knows, no attention has been paid to the subject of the computation of the elements of meteoric orbits, in any work in the English language on Theoretical Astronomy; but the general equations of Celestial Mechanics, as given in any standard treatise such as WATSON'S in English, and OPPOLZER'S in German, enable one to deduce the formulæ necessary for the derivation of the elements from the observed position of the radiant.

The object of this article is to present, in the simplest manner, the process of deriving these formulæ and to so arrange the latter that one may readily apply them. This process is greatly simplified by the well-founded assumption that the orbit of a member of a well-defined meteoric stream is, approximately at least, a parabola, having its focus at the *Sun's* centre and one of the nodes at that longitude in which the *Earth* is at the time of apparition of the meteor.

Hence the radius-vector r of the meteor may be assumed equal to R, or the radius-vector of the *Earth*, and the co-ordinates of the *Sun* may be taken as the heliocentric co-ordinates of the meteor.

The elements of the orbit of any body moving around the *Sun* are known if we know the heliocentric rectangular co-ordinates of the body, and the velocities parallel to them; there-

* Nautical Almanac Office, Navy Dept. Washington, D. C.

fore since the co-ordinates of the meteor, at the time of its appearance, are known, only the component velocities remain to be found.

Let l represent the longitude and b the latitude of the observed radiant; x, y, z, the heliocentric rectangular co-ordinates of the meteor; ξ, η, ζ, its geocentric co-ordinates; and X, Y, Z, the co-ordinates of the *Sun*. The component velocities parallel to the respective axes will be,

$$\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}; \frac{d\xi}{dt}, \frac{d\eta}{dt}, \frac{d\zeta}{dt}; \frac{dX}{dt}, \frac{dY}{dt}, \frac{dZ}{dt}$$

Then
$$\left.\begin{aligned} \frac{dx}{dt} &= \frac{d\xi}{dt} + \frac{dX}{dt} \\ \frac{dy}{dt} &= \frac{d\eta}{dt} + \frac{dY}{dt} \\ \frac{dz}{dt} &= \frac{d\zeta}{dt} + \frac{dZ}{dt} \end{aligned}\right\} \quad (1)$$

The velocities parallel to the geocentric co-ordinates may be obtained in the following manner: Expressing by g the ratio of the linear velocity of the meteor with respect to the *Earth*, to the velocity at unit distance, which velocity is known and is represented by the Gaussian constant k, we will have for the linear velocity of the meteor relative to the *Earth* the expression gk; hence the velocities parallel to the geocentric co-ordinates will be

$$\left.\begin{aligned} \frac{d\xi}{dt} &= -gk \cos l \cos b \\ \frac{d\eta}{dt} &= -gk \sin l \cos b \\ \frac{d\zeta}{dt} &= -gk \sin b \end{aligned}\right\} \quad (2)$$

The negative sign is used because the orbital motion is in a direction opposite to the direction of the line of sight.

The linear velocity in any conic section is expressed by the equation

$$V^2 = k^2 (1+m) \left\{ \frac{2}{r} - \frac{1}{a} \right\} \quad (3)$$

m representing the mass, a the mean distance and r the radius-vector of the moving body. In the case of the parabola, in which we assume the meteor to move, $\frac{1}{a}$ will vanish, and the

meteor being small, m may be neglected, and since r may be taken equal to R, equation (3) becomes

$$V^2=\frac{2k^2}{R}=\frac{dx^2+dy^2+dz^2}{dt^2} \qquad (4)$$

Squaring and adding equations (1), reducing by means of equations (2) and (4), and taking the plane of the ecliptic as the fundamental plane, so that $\frac{dZ}{dt}=0$; we will have the equation

$$g^2-\frac{2g}{k}\cos b\left\{\cos l\frac{dX}{dt}+\sin l\frac{dY}{dt}\right\}=$$

$$\frac{2}{R}-\left\{\frac{2}{R}-1\right\}=1; \qquad (5)$$

from which we can get the value of g. The velocities $\frac{dX}{dt}$ and $\frac{dY}{dt}$ are obtained in the following manner:

Let L=Longitude of *Sun*

π'= " " *Sun's* perigee=280°+1.′03(t−1850)

v=*Sun's* true anomaly

φ=Angle of *Earth's* eccentricity

Then since $L=\pi'+v$, $\frac{dL}{dt}=\frac{dv}{dt}$, (6)

We have also $X=-R\cos L$, $Y=-R\sin L$ (7)

Differentiating equations (7) with respect to the time, we get:

$$\frac{dX}{dt}=-\cos L\frac{dR}{dt}+R\sin L\frac{dv}{dt}$$

$$\frac{dY}{dt}=-\sin L\frac{dR}{dt}-R\cos L\frac{dv}{dt} \qquad (8)$$

to find $\frac{dv}{dt}$ and $\frac{dR}{dt}$ we take the well-known equation, expressing the double areal velocity, viz: $R^2\frac{dv}{dt}=2f=k(1+m)\sqrt{p}$ (8a)

neglecting the mass, substituting for p the semi-parameter, its value $a\cos^2\varphi$, and making a=1, we have

$$\frac{dv}{dt}=\frac{k\cos\varphi}{R^2} \qquad (9)$$

Differentiating the equation, $R=\frac{a\cos^2\varphi}{1+\sin\varphi\cos v}$, with respect to the time as contained in v, we will get $\frac{dR}{dt}=\frac{R^2}{\cos\varphi}\tan\varphi\sin v\frac{dv}{dt}$, or by substituting the value of $\frac{dv}{dt}$, as given in equation (9);

$$\frac{dR}{dt}=k\tan\varphi\sin v \qquad (10)$$

The equation $R=\frac{\cos^2\varphi}{1+\sin\varphi\cos v}$ gives $\frac{\cos^2\varphi}{R}=1+\sin\varphi\cos v$

Then equations (8) may be written

$$\left.\begin{aligned}\frac{dX}{kdt}&=\sin L+\sin\varphi\sin\pi'=s\sin L'\\ -\frac{dY}{kdt}&=\cos L+\sin\varphi\cos\pi'=s\cos L'\end{aligned}\right\} \qquad (11)$$

Squaring and adding equations (11) and reducing by equation (3), we get $s^2=\frac{2}{R}-1$; (12)

and by neglecting the square of the eccentricity; $s=\frac{1}{R}$; (12a)

Multiplying the first of equations (11) by cos L and the second by sin L and subtracting the latter from the former, we will have, after reduction, sin $(L'-L)=\sin\varphi\sin(\pi'-L)$; or, since $(L'-L)$ is a small arc, we may take,

$$L'=L+\sin\varphi\sin(\pi'-L); \qquad (13)$$

Equation (5) may then be written

$$g^2+2g\frac{\cos b\sin(l-L')}{R}=1; \qquad (14)$$

The solution of equation (14) is facilitated by taking an auxiliary angle z, so that

$\frac{\cos b\sin(l-L')}{R}=\cot z$, we will then have,

$$g=\frac{\pm1-\cos z}{\sin z}=\tan\frac{1}{2}z \qquad (15)$$

By restricting z to less than 180°, sin z will always be positive, and, since the ratio g must be positive, 1 will have the upper sign only. By substituting the value of g so found, in equations (2), we will have the velocities parallel to the geocentric axes, and we can now proceed to the determination of the elements.

Taking the fundamental equations of planetary motion:

$$\frac{d^2x}{dt^2}+k^2\,(1+m)\frac{x}{r^3}=0$$

$$\frac{d^2y}{dt^2}+k^2\,(1+m)\,\frac{y}{r^3}=0$$

$$\frac{d^2z}{dt^2}+k^2\,(1+m)\frac{z}{r^3}=0$$

and multiplying the first of these equations by y and the second by x, and subtracting the latter result from the former, and treating the rest in like manner, so as to get rid of the second term of the first member of each equation, we will have after integrating:

$$\left.\begin{aligned}\frac{xdy-ydx}{dt}&=c\\ \frac{xdz-zdx}{dt}&=c'\\ \frac{ydz-zdy}{dt}&=c''\end{aligned}\right\}\qquad(16)$$

c, c' and c'' are the constants of integration, and they represent double the areal velocities, parallel to the axes x, y and z, respectively.

Let i represent the inclination of the plane of the meteoric orbit to the plane xy; and let Ω denote the angle between the axis x and the line of intersection of the orbital plane with the plane xy; then denoting the double areal velocity by $2f$, and having from equations (16,) c, c', and c'', as the components of this double velocity with respect to the axes x, y and z we will have, since $2f=k\sqrt{p}$:

$$\left.\begin{aligned}c&=2f\cos i &&=k\sqrt{p}\cos i &&=x\frac{dy}{dt}-y\frac{dx}{dt}\\ c'&=2f\cos\Omega\sin i &&=k\sqrt{p}\cos\Omega\sin i &&=x\frac{dz}{dt}-z\frac{dx}{dt}\\ c''&=2f\sin\Omega\sin i &&=k\sqrt{p}\sin\Omega\sin i &&=y\frac{dz}{dt}-z\frac{dy}{dt}\end{aligned}\right\}\qquad(17)$$

Substituting for the semi-parameter p its equivalent in the parabola, viz: $2q$, q representing the perihelion distance, and taking the *Sun's* rectangular co-ordinates for the heliocentric co-ordinates of the meteor, so that $X=-R\cos L$ and $Y=$

$-R\sin L$, we will have after reducing by the relations in equations (1) and (2):

$$\left.\begin{aligned} k\sqrt{(2q)}\cos i &= R\sin L\frac{dx}{dt}-R\cos L\frac{dy}{dt} \\ k\sqrt{(2q)}\cos\Omega\sin i &= -R\cos L\frac{dz}{dt}=gkR\cos L\sin b \\ k\sqrt{(2q)}\sin\Omega\sin i &= -R\sin L\frac{dz}{dt}=gkR\sin L\sin b \end{aligned}\right\} \quad (18)$$

Since in the two last of equations (18) $k\sqrt{(2q)}\sin i$ and gkR must be always positive, Ω will be equal to L when $\sin b$ is positive, but when $\sin b$ is negative, Ω will be equal to $L+180°$. From them also we get $\sqrt{(2q)}\sin i=\pm gR\sin b$; that sign to be taken that will make the first member positive.

From the first of equations (18) we get, after reducing by the relations in (1), (2), (12) and (12*a*)

$$\sqrt{(2q)}\cos i=\sin L\,(\sin L'-gR\cos b\cos l)+\cos L\,(\cos L-gR\cos b\sin l).$$

Since $\cos(L-L')$ differs but little from unity, we may write this equation, $\sqrt{(2q)}\cos i=1+gR\cos b\sin(l-L)$.

Then we will have:

$$\left.\begin{aligned} \sqrt{(2q)}\sin i &= \pm gR\sin b \\ \sqrt{(2q)}\cos i &= 1+gR\cos b\sin(l-L) \end{aligned}\right\} \quad (19)$$

from which to obtain the elements i and g. To derive the true anomaly v, from which we also get the perihelion longitude π; through the equation $\pi=L-v+180°$, we differentiate the equation $r=\frac{q}{\cos^2\frac{1}{2}v}$ with respect to the time, and get thereby $\frac{dr}{dt}=r\tan\frac{1}{2}v\frac{dv}{dt}$, or, substituting the value of $\frac{dv}{dt}$ from equation (8*a*) $\frac{dr}{dt}=\frac{k\sqrt{(2q)}}{r}\tan\frac{1}{2}v$; whence

$$\tan\tfrac{1}{2}v=\frac{r\frac{dr}{dt}}{k\sqrt{(2q)}};\text{ but}$$

$\frac{rdr}{dt}=\frac{xdx+ydy}{dt}$, then through equations (1), (2), (12) and (12 *a*), and taking $r=R$, we will have $\frac{rdr}{kdt}=gR\cos b\cos(l-L)-\sin(L'-L)$, from which we get

$$\tan\tfrac{1}{2}v=\frac{gR\cos b\cos(l-L)-\sin(L'-L)}{\sqrt{(2q)}};$$

$\frac{1}{2}v$ is to be taken between the limits $-90°$ and $+90°$.

From the equation, $r=\frac{q}{\cos^2 \frac{1}{2}v}$, we get $q=R\cos\frac{1}{2}r$. This value of q should agree with that obtained from equations (19), if the computation is not in error; it may therefore be used as a check. We may express the value of $\sin\varphi=e=$eccentricity of the *Earth's* orbit in minutes of arc; its logarithm is, therefore, 1.7609.

Then we will have the following formulæ for the computation of the parabolic elements of the orbit of a meteor stream, from the longitude and latitude of the radiant point:

$$\log e'=1.7609$$

$$\pi'=280^\circ\ 21'+1.'03(t-1850)$$

$$L'-L=e'\sin(\pi'-L)$$

The value $L'-L$ will be in minutes of arc;

$$\cot z=\frac{\cos b\sin(l-L')}{R};\ z \text{ to be less than } 180^\circ$$

$$g=\tan\tfrac{1}{2}z$$

$$f=Rg$$

$$\sqrt{(2q)}\sin i=\pm f\sin b \quad \begin{cases} \text{Upper sign when } \sin b \text{ is positive.} \\ \text{Lower } \text{“} \quad \text{“} \quad \text{“} \quad \text{“} \quad \text{“} \text{ negative.} \end{cases}$$

$$\sqrt{(2q)}\cos i=1+f\cos b\sin(l-L),$$

$\Omega=L$ when $\sin b$ is positive,

$\Omega=L+180^\circ$ when $\sin b$ is negative.

$$\tan\tfrac{1}{2}v=\frac{f\cos b\cos(l-L)-\sin(L'-L)}{\sqrt{(2q)}},$$

$\frac{1}{2}v$ to be taken between the limits -90° and $+90^\circ$,

$\pi=L-v+180^\circ$,

Check: $q=R\cos^2\frac{1}{2}v$.

Elements derived by means of the above formulæ will suffice to disclose the identity of the orbit of a meteoric stream with a cometary orbit, if such identity should exist. Then if periodicity can be well established, other assumptions as to the eccentricity may be made, and elliptic elements computed. It is hoped that this presentation of formulæ, derived from authentic sources may prove useful to those readers of the "MESSENGER" who are interested in this comparatively new branch of astronomy.

A computation of the parabolic elements of the orbits of the twenty meteoric showers whose radiants and dates of maximum are given by Mr. W. F. DENNING on page 300 of the December number of the MESSENGER, furnishes the following results which I tabulate in such a manner that they will correspond to the date given us by Mr. DENNING.

Night of max.	Radiant Point. R. A.	Radiant Point. Decl.	π	Ω	i	q	Direction of motion
1885			° ′	° ′	° ′		
July 8	245°	+52°	293 58	106 54	30 06	1.0127	Direct
" 13	271	+21	335 50	110 40	24 58	0.8727	"
" 12	329	+36	345 40	110 42	86 03	0.8000	Retrograde
" 9	280	−14	2 56	107 51	7 08	0.6392	Direct
Aug. 17	345	0	102 39	145 10	16 26	0.1330	"
" 17	345	+53	16 00	145 10	79 01	0.8255	"
" 20	5	+12	119 27	148 04	55 11	0.0618	Retrograde
Sept. 4	346	0	81 40	162 34	6 27	0.4241	Direct
" 3	354	+38	75 24	161 36	65 56	0.4706	"
" 3	253	+54	357 00	161 36	32 58	1.0057	"
" 8	62	+36	18 27	166 27	25 53	0.9302	Retrograde
" 9	335	+71	14 28	167 25	65 03	0.9514	Direct
" 15	76	+57	35	173 16	57 18	1.0007	Retrograde
" 8	335	+28	60 31	166 27	31 49	0.6416	Direct
" 15	5	+12	116 19	173 16	17 30	0.2284	"
" 15	13	+ 6	132 21	173 16	1 08	0.1228	"
Oct. 12	103	+33	50 23	199 50	17 37	0.9280	Retrograde
" 8	42	+55	106 08	195 52	83 26	0.4968	Direct
" 16	143	+49	59 21	203 48	57 16	0.9032	Retrograde
" 7	31	+18	149 57	194 53	13 04	0.1459	Direct

In the above table π represents the longitude of the perihelion of the meteoric orbit, Ω its ascending node, i its inclination to the ecliptic and q its perihelion distance, the *Earth's* mean distance from the *Sun* being taken as the unit.

I also append the following table of comparison between the apparent velocities noted by Mr. DENNING and the true linear velocities relative to the Earth, as derived from my computation on the hypothesis of parabolic motion.

Date	Appearance noted by Mr. Denning	Linear Velocity	Date	Appearance noted by Mr. Denning	Linear Velocity
1885			1885		
July 8	Meteors very slow	14 miles per s.	Sept. 8	Very swift, streaks	43 miles per s.
" 13	Slow, faint	14 " " "	" 9	Medium speed	25 " " "
" 12	Swift, streaks	32 " " "	" 15	Very swift, streaks	39 " " "
" 9	Slow, long paths	16 " " "	" 8	Slow, faint	19 " " "
Aug 17	Medium speed	26 " " "	" 15	Slow	24 " " "
" 17	Very swift	29 " " "	" 15	Swift	26 " " "
" 20	Medium speed	33 " " "	Oct. 12	Very swift, streaks	44 " " "
Sept. 4	Slow, bright	20 " " "	" 8	Slow	30 " " "
" 3	Very swift	27 " " "	" 16	Swift, streaks	39 " " "
" 3	Slow, yellow	15 " " "	" 7	Slow, bright	25 " " "

I think that the correspondence between the above named quantities is somewhat remarkable, and tends to strengthen the hypothesis of motion in a conic section whose eccentricity differs but little from unity. It also shows the accuracy with which a skilled observer can estimate a quantity so difficult to obtain.

WASHINGTON, D. C. December 10, 1885.

GALLE'S CATALOGUE OF COMETS FROM 1860 TO 1884.

(*Continued from page 10.*)

(240) T_1. A. N. 93: 319, 94: 157. Found with the help of SEELIGER'S ephemeris April 3, by STEPHAN at Marseilles; last observed August 1 by ANDRE and BAILLAUD at Paris. First return of TEMPEL'S first comet. Its orbit has the least eccentricity (e=0.46) of all the comet orbits yet known.

251 T_2. Annuaire 1884 p. 229. Discovered by TEMPEL at Milan July 3; last observed by HIND and PLUMMER at Twickenham October 20. The second of the periodic comets discovered by TEMPEL: period, about 5 years (U=5.2 years), the shortest period next to that of ENCKE'S comet.

(163) F. A. N. 80: 337. Found with MOELLER'S very accurate ephemeris, September 3 by STEPHAN at Marseilles, and observed there November 28 and 30; last observed December 23 by PETERS at Clinton. On account of its faintness, not seen elsewhere.

252. A. N. 92: 72. Discovered August 20 by BORELLY at Marseilles; last observed September 20 by STRASSER at Kremsmuenster and by HALL at Washington. From five normal places, with the perturbations by *Venus*.

253. A. N. 83: 50. Discovered August 23 by PAUL HENRY at Paris; last observed by PALISA at Pola November 28 and December 17, the latter observation only approximate. The elements above include the post-perihelion observation of November 28.

(171) Br. A. N. 93: 183. Found August 31 by STEPHAN at Marseilles; last observed by PLUMMER at Twickenham, October 26.

254. A. N. 87: 122. Discovered November 10 by COGGIA at Marseilles, and November 11 by WINNECKE at Strassburg. Observed for only a few days:—by WEISS at Vienna till November 15. The computed orbits show a resemblance to the very roughly observed comets (No. 127 *b*,) 1818 I, and the above elements by WEISS assume a period of 6.2022 years.

255. A. N. 94: 200. Discovered by WINNECKE at Strassburg February 20; observed February 20–25; last, at Pola by

PALISA and at Vienna by SCHULHOF. The elements given above are deduced from all the observations made during this short time.

256. Wien. Ak. S. B. 77 (1878). Discovered April 11 by WINNECKE at Strassburg, April 15 by BORELLY at Marseilles and April 18 by TEMPEL at Milan. Last observed June 17 by SCHULHOF at Vienna. The above elements are from nine normal places, embracing all the observations.

257. Wien. Ak. S. B. 86, A. N. 103: 63. Discovered by COGGIA at Marseilles April 17. At first faint, but it was approaching the *Earth*, and finally became one of the brightest of the more recent comets. In the northern hemisphere it was observed to July 17, (SCHMIDT at Athens saw the tail even to July 23) and then in the southern hemisphere from July 27 to October 18; last observed by THOME at Cordoba. The orbit by v. HEPPERGER is deduced from 618 observations divided into seventeen normals, and takes account of perturbations.

258. Wien. Ak. S. B. 1882, A. N. 104: 223. Discovered August 19 by COGGIA at Marseilles; last observed November 14 by PLUMMER at Orwell Park. This orbit, computed from seven normal places, is an ellipse of 306.043 years' period. The observations are not satisfied by a parabola.

259. Wien. Ak. S. B. 1878 July. Discovered July 25 by BORELLY at Marseilles; last observed at Hamburg by RUMKER October 20. An ellipse computed from nine normal places represents the observations rather better than a parabola, though differing very little from the latter. Very nearly the same orbit was found from five normals by GRUBER and KURLAEDER (A. N. 91: 79).

260. Wien. Ak. S. B. 1878 November, A. N. 94: 190. Discovered December 6 by BORELLY at Marseilles; last observed January 7, 1875 by BRUHNS at Leipzig. The above orbit embraces the few observations which could be obtained.

(131) W. A. N. 97: 338. Found February 1 by BORELLY at Marseilles, and visible for a short time only, during the early morning hours. Last observed February 15 by SCHIAPARELLI at Milan.

(96) E. Mem. de St. Petersb. 26 No. 2: 121. Found Janu-

ary 26 by HOLDEN and TUTTLE at Washington, and January 27 by STEPHAN at Marseilles; observed at Moscow by BREDICHIN to April 10, and after perihelion only three times, May 7 and 9 at Windsor by TEBBUTT, and May 17 at Melbourne by WHITE.

261. A. N. 100: 238. Discovered February 8th by BORELLY at Marseilles, and February 9 by PECHULE at Copenhagen, where it was also longest observed (to April 31.) These elements rest on five normal places.

262. A. N. 93: 45. Discovered by WINNECKE at Strassburg April 5, and by BLOCK at Odessa April 10. Last observed July 13 by SCHMIDT at Athens. The orbit is derived from about 280 observations,and takes account of perturbations.

263. Wien. Ak. S. B. 78: 976. Discovered April 11 by SWIFT at Rochester, April 14 by BORELLY at Marseilles, April 16 by BLOCK at Odessa. BLOCK had, indeed, seen the comet on April 10, but he had not recognized the cometary character. The orbits computed by NICHOL (A. N. 93: 42) and by POENISCH (A. N. 100: 63) both from normal places, show a very close agreement with ZELBR's orbit given above.

(189) d'A. Annales de l'observ. de Paris 14 p. B. 25. Found July 9 by TEMPEL at Arcetri, and by COGGIA at Marseilles; also July 13 by SCHMIDT at Athens; last observed September 10 at Athens.

264. Wien. Ak. S. B. 1882 January, A. N. 101: 239. Discovered October 2 by TEMPEL at Florence. Observed only to October 14; last at Leipzig by PETER, at Milan by SCHIAPARELLI, at Orwell Park by PLUMMER, and at Pola by J. PALISA. The elements above are derived from all the published observations, through four normals.

265. M. N. 38: 56, A. N. 91: 91. Discovered by COGGIA at Marseilles September 13. The last observation is by J. PALISA at Pola, December 10. Above elements from observations to October 31.

266. A. N. 97: 277. Discovered July 7 by SWIFT at

Rochester, and observed on only four days, July 7, 10, 19 and 23, — by PETERS at Clinton. The above is the most probable orbit from these four observations.

(96) E. A. N. 92: 193. Found August 3 by TEBBUTT at Windsor; last observed September 6 at Cordoba by THOME.

(251) T_2. Annuaire 1884 p. 229. TEMPEL's second comet; found July 19 by TEMPEL at Arcetri, and last observed there December 18; seen also December 21.

(171) Br. A. N. 93; 185. Found January 14 by TEMPEL at Arcetri; first accurate observation February 26 by TEBBUTT at Windsor; and last observed May 23 by PETER at Leipzig.

267. Diss. inaug. Vratisl. 1883, A. N. 108: 102. Discovered by SWIFT at Rochester June 16; last observed August 23, at Cambridge, U. S., by WENDELL. The orbit depends on six normal places, embracing nearly all the observations.

(240) T_1. A. N. 94: 158. Second return of TEMPEL's first comet. Found by TEMPEL himself at Arcetri April 24, and also last observed by him July 8.

268. A. N. 96: 31. Discovered by Hartwig at Strassburg August 24; last observed on September 18 at Konigsberg by FRANZ. The above elements from August 28, September 8 and 13.

269. Wien. Ak. S. B. 81 (1880). Discovered by A. PALISA at Pola August 21; last observed at Rome October 22 by TACCHINI. Above orbit from fifty-five observations arranged in five normal places.

270. A. N. 102: 88. The head of this comet was first seen by GOULD at Cordoba, February 4, the tail having been noticed on January 31. In its general appearance, as well as in the elements of its orbit it was remarkably like Comet 1843 I. On account of the rapid decrease of its brightness it could not be observed, either in the southern hemisphere or here, later than February 19 (last at Cordoba by GOULD). The investigations in regard to its orbit cannot be considered as en-

tirely definitive. The above orbit by W. MEYER, founded on seven normal places assumes hypothetically a period of 36.844 years going back directly to Comet 1843 I.

271. Wien. Ak. S. B. 1881 June, A. N. 100: 383. Discovered April 6 by SCHAEBERLE at Ann Arbor. Last observed, before perihelion, on June 8, by KORTAZZI at Nikolaiev, and after perihelion, September 8–11, by BIGOURDAN at Paris. The orbit by J. MAYER depends on eight normal places, and differs very little from one computed by BIGOURDAN from three normals April 8 to May 18 (C. R. 91: 74).

272. A. N. 105: 362, 106: 121. Discovered September 29 at Strassburg by HARTWIG and September 30 at Ann Arbor by Harrington; last observed by TEMPEL at Arcetri November 30. From seven normal places, September 30 to November 30, which are well represented by the above orbit.

(244 T_3.) A. N. 99: 14, C. R. 91: 967. Discovered October 10 at Rochester by SWIFT, also November 27 at Dun Echt by J. G. LOHSE. Observed to January 20 by WENDELL at Cambridge, U. S. The identity with Comet 1869 III (TEMPEL) (which is now designated as the third periodic comet discovered by TEMPEL) was soon recognized, and with this assumption the above ellipse representing satisfactorily both returns was computed.

COOPER at Sheffield detected a comet December 21, 1880 and afterwards saw it December 21 and 25, but it was not seen elsewhere. Dr. OPPENHEIM has attempted to derive an orbit from the three positions, which are merely estimated to half a degree:

T=Nov. 8, 19h 32m. π=184° 2′. Ω=257° 36′. i=50° 48′. Log. q=9.5874. R. These however represent the middle place to only 19′. (A. N. 100: 73. The Observatory 4: 30, 217.)

273. C. R. 92: 172. Discovered at Copenhagen by PECHULE December 16; observed at Paris by BIGOURDAN to March 31. Above elements are from observations of December 16th, January 1 and 19.

(163) F. Berl. Astr. Jahrb. 1882: [138]. First detected August 2, 1880 by COMMON at Ealing; afterwards found by TEMPEL at Arcetri, August 11, and first observed by the latter August 25. Observations continued at Washington by HALL to March 27, 1881.

274. A. N. 105: 315. Discovered by SWIFT at Rochester April 30, and only observed May 2–11; last (May 11) by BORELLY at Marseilles. The above orbit is derived from four normal places, May 3–11.

A comet was seen by BARNARD at Nashville, 1881 May 12 and 13, near *α Pegasi*, but it was not found May 14 and subsequently. *See* A. N. 100: 127, and Copernicus 1: 140.

275. C. R. 93: 660. A bright comet,—first seen in the southern hemisphere, May 22, by TEBBUTT at Windsor, and a month later it appeared in the northern hemisphere, and was visible to the naked eye until the beginning of November. It was observed three months longer, (nearly nine months in all) and was last seen February 14, 1882 by WENDELL at Cambridge, U. S. Soon after its discovery the resemblance of its orbit to that of the comet of 1807 was noticed, but further computation did not establish their identity. A great many computations of the orbit of this comet were made (more than thirty) but so far no one has taken in the whole series of observations. An orbit by BOSSERT was derived from eight normal places (with 423 observations, May 21 to September 29) and gives a period=2954.5 years. The orbit by DUNER and ENGSTROM shows a remarkably close agreement (A. N. 100: 284.) The latter was formed from four normal places and represents the observations from May 27 to September 2 within a few seconds. Other elements differ from BOSSERT's only in the 6th decimal, the period, also, coming out 2954 years.

276. Diss. inaug. Kiel 1884. A. N. 108: 228, 437. Discovered July 14 by SCHAEBERLE at Ann Arbor. visible to the naked eye at the same time as the preceding great comet, 1881 III. In Europe it was observed to September 13 by

TEMPEL at Arcetri; in the southern hemisphere by TEBBUTT at Windsor to October 15, at Melbourne by WHITE to October 8 (seen October 9 and 21;) at the Cape by GILL and ELKIN to October 18. The above is the most probable orbit from all the observations, and allows for perturbations.

277. Copernicus 3: 15, A. N. 105: 111. Discovered October 4 by DENNING at Bristol; last observed November 19 at Strassburg by WINNECKE. The orbit proved to be elliptic (U= 8.86 years). In PLUMMER'S discussion, from eight normal places, perturbations are allowed for, and the star places are corrected from recent observations.

278. A. N. 102: 269. Discovered by BARNARD at Nashville, Tennessee, September 17; last observed at Cambridge, U. S., October 27 by WENDELL. The above orbit includes all the observations made in this short time.

(96) E. Bulletin de St. Petersb. 27, A. N. 100: 111. Found, by BACKLUND'S ephemeris, August 20, at Strassburg by WINNECKE and HARTWIG, and at Leipzig by PETER; also August 21 by TEMPEL at Arcetri and by SCHMIDT at Athens; more accurately observed August 24 by STRUVE at Pulkowa and August 25 by WINNECKE at Strassburg; last observed November 11 by TACCHINI at Rome.

279. C. R. 93: 1122. Discovered November 16 by SWIFT at Rochester; last observation January 12, 1882, by J. PALISA at Vienna. Elements from November 17, 27, December 12, 21.

280. A. N. 107: 94, M. N. 44: 12. Discovered March 17 by WELLS at Albany, U. S. Bright comet, and observed at the time of perihelion in full daylight. Last observed August 16 at the Cape of Good Hope by FINLAY. The above elements are derived from six normal places March 26 to August 7.

During the total solar eclipse of May 16, 1882, a comet was seen close to the *Sun* at Sohag in Egypt. Further information in regard to it will be found in A. N. 102: 271. The Observatory 5: 209, C. R. 94 and 95 [also Phil. Trans. Roy.

Soc. 175: 261]. Compare also HOLETSCHEK, Wien. Ak. S. B. 1883, November.

281. A. N. 104: 157. This great comet was discovered* with the naked eye, early in September at several places in the southern hemisphere: September 3 at Auckland, September 6 at Cordoba by GOULD, September 7 at Melbourne by ELLERY, September 8 at the Cape by FINLAY, September 11 at Rio de Janeiro by CRULS. It developed into one of the grandest comets of this century, comparable only with the Comet of 1811, and DONATI's Comet, 1858 VI.

On account of the unusual form of its orbit, and the great variety of new and strange physical phenomena, which could be observed with all our modern appliances, this comet must be regarded as standing alone in the history of astronomy. At the time of its perihelion, September 17 and 18, it was quite generally seen at many places in Europe and America,—even with the naked eye,—close to the *Sun*. COMMON at Ealing discovered it near the *Sun*, September 17, and the astronomers at the Cape observatory succeeded in observing it pass before the *Sun's* disk, where it completely disappeared. This would not be the place to go into further description. Observations of the comet's position were continued to June 1, 1883, when it was last observed by THOME at Cordoba. The above orbit depends on nine normal places, before and after perihelion, from September 8 to November 14. It shows, as was remarked very soon after the discovery, a striking resemblance to the orbits of the great comets, 1843 I and 1880 I, which is all the more surprising, since an identity of the two latter comets did not seem to accord entirely with the observations.

Besides a peculiar, broad, but faint* nebulous veil around the comet, SCHMIDT at Athens discovered on October 8th an irregu-

* A letter, recently received from Dr. GALLE, contains the following note in regard to this comet (1882 II): "The first actual observation of this great comet seems to have been made by FINLAY at the Cape, on September 7. It was seen with the naked eye at the Cape, as early as September 1, at Auckland September 3, and a few days later in South America and in Australia. The nebula near the comet was discovered by SCHMIDT at Athens, on October 9 (not October 8), and also, independently, on the same day, but a few hours later, by HARTWIG in the southern hemisphere." [W. C. W.]

lar nebulous mass, apparently 4° southwest of the main comet, and separated entirely from it. This seemed to form a sort of companion comet, following approximately the motion of the larger comet (A. N. 103: 209, also HARTWIG, A. N. 106: 231). For attempts to determine the orbit of this nebulous object (the orbits do not differ very much from that of the main comet) *see Zelbr*, Wien. Ak. S. B. 86, and v. HEPPERGER, ib. 87.

Similar nebulous masses were seen at a little distance from the comet, somewhat later by BARNARD at Nashville, BROOKS at Phelps and LA CAILLE at Olinda.

282. A. N. 104: 219. Discovered by BARNARD September 13 at Nashville, Tennessee; last observed December 8 by TEBBUTT at Windsor. Above orbit from five normals, September 19 to November 11.

283. M. N. 44: 88. Discovered February 23 by BROOKS at Phelps (N. Y.) and a little later on the same day, by SWIFT at Rochester (N. Y.); last observed April 15 by MILLOSEVICH at Rome. The above orbit is computed from March 3, 23 and April 12.

284. A. N. 108; 264. Discovered 1884 January 7th by Ross at Elsternwick near Melbourne; seen by ELLERY at Melbourne to February 19; last observation, however, not accurate Above orbit from five observations, January 12 to February 4.

On the 25 and 27 of December, 1883, a little before sunrise a bright comet was seen at New Norfolk, Tasmania, at an altitude of 8° or 10° above the horizon. Further particulars are found in A. N. 108: 275, 423 and The Observatory 7: 141.

(124) P. Bull. astr. 1: 26, A. N. 108; 10. For some time attention has been called by the very creditable work of SCHULHOF and BOSSERT to the return during this year, of the comet discovered by PONS in 1812 (for which an elliptic orbit had been computed by ENCKE) but quite unexpectedly on September 1, 1883, a comet was found by BROOKS of Phelps, N. Y., whose identity with the comet of 1812 was soon recognized. A great many observations were obtained in both hemispheres, and in

Australia and at the Cape it was followed to the end of April, and at Cordoba (Argentina) by W. G. DAVIS to May 26, 1884. A provisional correction to the orbit from five normal places (without, for the present, a change of the eccentricity) gave the above elements with a period of about 72 years.

285. A. N. 111: 15. Discovered by BARNARD at Nashville July 16; observed at Nice by PERROTIN to November 20. The comet, soon after the first computations, proved to be elliptic with a period of 5.4 years. The above orbit includes observations from July 26 to October 23, and agrees very closely with one deduced by MORRISON (M. N. 45: 50) from observations of July 25 to September 23.

286. A. N. 110: 207. Discovered by MAX WOLF at Heidelberg, September 17; observed by YOUNG at Princeton, N. J., to April 6. The above elements (derived from observations September 20–November 7) showed a small deviation from the observations. The orbit of this third comet of 1884 also proved to be elliptic, with a period of 6.8 years, and according to these elements a very near approach of the comet to the planet *Jupiter* must have taken place in May, 1875.

COMETS OF 1885.

W. C. WINLOCK.

[For the Messenger.]

The following list will bring the table of comets (1860–84) given in the SIDEREAL MESSENGER for January, 1885 (4: 5–8), down to date. Comet 1884 (Wolf) finally became Comet 1884 III. It may be a little premature to call the comet discovered by Mr. BROOKS on December 26, 1885, "Comet 1885 V;" but its designation will be changed, only in case a comet should now be found, passing perihelion before November 29, 1885.

Comet 1885 I = Comet (*d*) 1884.
= ENCKE's Comet.
Comet 1885 II = Comet (*a*) 1885.
= BARNARD's Comet.
Comet 1886 III = Comet (*c*) 1885.
= BROOKS' Comet.
Comet 1885 IV = Comet (*b*) 1885.
= TUTTLE's Comet.
Comet 1885 V = Comet (*f*) 1885,
= BROOKS' Comet.
Comet 1886 (FABRY) = Comet (*d*) 1885.
= Paris Comet.
Comet 1886 (BARNARD) = Comet (*e*) 1885.

THE NOVA IN ANDROMEDA.

W. H. NUMSEN.

[For the Messenger.]

In the December No. the question of sudden changes in the brightness of the nova had been discussed by various observers. Inasmuch as my telescope was turned upon this object upon nearly every clear night, from September 1 to November 10, perhaps my experience may not be altogether without interest. I think there can be no question that marked changes in the intensity of its light have taken place, even in the course of the same observation; but whether they were real, or merely atmospheric, well—there's where the difficulty comes in.

In the earlier stages of the nova this peculiarity of its light was not much noticed, the star seeming to shine with a pretty steady, planetary sort of light, especially on September 1 and 2, but later on after it had dropped to tenth magnitude and under, the twinkling and flashing out of its light seemed to increase. Generally, I was inclined to attribute this to the state of the atmosphere, and indeed upon some occasions felt sure that the phenomenon was merely an atmospheric one. But upon some other occasions I could not resist the impression that the star actually did flare up and go down again.

Especially was this the case on the night of October 10, when a watch of forty to forty-five minutes was kept upon it. The night was clear, no clouds, no wind and no remarks in my note-book as to definition being bad. On this night, to such an extent did it twinkle and flicker, that I could not satisfy myself as to what magnitude to assign to it.

At times it would be invisible, then plain and apparently about as bright as *y* or *z*, then again not much brighter than *w*. It seemed to throb and pulsate, and reminded me of the last expiring flashes of a candle going out. Invisible for awhile, then flashing out bright.

On the night before it was about as bright as *y* or *z*, and I put its approximate magnitude at about $10\frac{1}{2}$, but on this night its changes in brightness were so marked that I could not satisfy myself.

On 14th it was estimated as between *y* or *z* and *w*, $10\frac{3}{4}$ to 11. On the 15th and 16th about the same. From these dates on it was never seen steadily, even with the best of air, but would only be seen flashing out at times after a careful watch, enough to satisfy me that it was still there. On the 21st, with powers up to 200, after a careful watch of twenty-five minutes, it was only suspected once or twice, but the *Moon* was very bright. On the 26th, with 200, it was certainly seen at intervals, but required steady watching, and was not much brighter, if any, than *w*. On the 31st, after thirty minutes watch I felt sure it was still there, for although invisible most of the time, yet at times a real stellar point would flash out.

On November 4 and 10 I was not certain as to seeing it. Only about fifteen minutes were devoted to it on the 4th, and the night was not so clear. On the 10th, the night being extremely clear, after twenty-five minutes' watching, towards the end I could not resist the impression that occasionally a faint point of light was visible at about the position where the nova was before, but could not locate it positively. When the star was at its lowest it was still considerably brighter than the small star about $1\frac{1}{2}'$ to $2'$ almost due preceding the position of the nova. I think this is the star mentioned by Mr. KNOTT at the November meeting of the Royal Astronomical Society, as being estimated by him at about 12.4 magnitude. It was first noticed about October 1, in looking around for some fainter comparison star, than I had been using, but there was too big a difference between it and the nova, so I used the star *w*. At the time I estimated its magnitude at about the 12th, although it was seen pretty easily on any good night with p. 120, and in fact was first noticed with that power.

The diagram, you were kind enough to print, was only intended to illustrate the positions of the unknown stars *x*, *y*, *z* and *w*, as numerous other stars were in the same field, some brighter and some fainter. On page 305 a small typographical error has crept in where you have the estimated magnitude of star *z* as $10\frac{1}{4}$ instead of $10\frac{1}{2}$. In my later estimates of these four stars, I have assumed *y* as $10\frac{1}{2}$. This would make *x* about 10.2, *z* 10.6 and *w* about $11\frac{1}{4}$. Of course having no standard comparison stars for such small magnitudes, I cannot pretend to very great exactness in the matter, but I think the above will represent approximately the relative brightness of the four different stars. ARGELANDER has both *d* and *e* as 9.5, but to me there is always a very perceptible difference between them, probably about .4 to .5. I think there is also fully .3 difference between *a* and *f*.

THE SUMMATION OF CO-ORDINATES.

HENRY M. PARKHURST.

[For the Messenger.]

In the rapid approximation of the course of a new comet, I have found two mechanical devices extremely convenient. The first is a line of squares, constructed in the following manner. At one-fourth of the distance between the two ends of the scale is the zero-point, from which the line is to be set off equally in both directions, by means of a scale of equal parts, the distances being the squares of the numbers marked upon the scale. It is convenient to have several of these lines, with different units of distance. In use, extend a pair of dividers from the smallest co-ordinate on one side of the zero-point, to the next smallest upon the other side, and then from the third co-ordinate outward, which will reach to the sum of the three.

The second device is no less simple. Upon a small sheet of squared paper, such as is used by surveyors, each tenth division being marked by a heavier line, is drawn a graduated arc of 90 degrees, with the center at one corner. A paper rule, divided in like manner, is fastened by a pin, to turn upon that corner as a center. Now let x, y, z, represent the geocentric co-ordinates of a comet, of which the right ascension and declination are required. First let the rule pass through the point of junction of x, y, or any multiple thereof, and the right ascension will be indicated upon the arc, and the curtate distance d upon the rule. Next, let the rule pass through the point of junction of d, z, or any multiple thereof, and the declination will be indicated upon the arc.

As an illustration of my method of approximation, from the ephemeris of the late Paris comet, for December 12, and 20, I obtained the heliocentric co-ordinates x, y, z, for each date. Their difference gave l, m, n, the motion in eight days. The momentum of the comet would carry it the same distance in the next eight days, and the *Sun's* attraction would cause it also to fall towards the *Sun*, the fall being x, y, z, each divided by $53r^3$. This gives x, y, z, for December 28. Thence we have a new l,m,n, giving the modified momentum, and with the new value of r^3 can determine the fall for the following eight days. Continuing this process, using three decimal places only, I followed the comet up to July, the time of perihelion closely corresponding to the elements given. It was only necessary to apply the *Sun's* co-ordinates for any desired dates, to obtain the geocentric co-ordinates, with which, by the squared sheet, about four

inches by five, the positions of the comet could be obtained, nearly, if not quite as accurate as the orbit itself would be likely to give them. It only required about twenty-four figures for each heliocentric position, the value of r being taken from the line of squares, its cube from a table of cubes, and the fall being mentally computed; and about as many more for each geocentric position, for the co-ordinates and the final result. It is hardly necessary to say that this mode of working is only useful for rough approximations, since it is practically impossible to avoid the accumulation of errors from the continually varying fall towards the *Sun*.

Applying the same method to BARNARD'S comet, with equal success, and verifying by a direct computation of one position at the perihelion, I discovered that it will be in a good position for observation in this latitude, for the month after perihelion passage, next June, when it will be at least two hundred times as bright as at the time of discovery, although previous to that time it will have sunk below our horizon. It is to be hoped that further observations may not materially modify the form of the orbit.

BROOKLYN, New York, December 23, 1885.

SOLAR ECLIPSE OF 1886

A total eclipse of the *Sun* will occur on the 29th of August, 1886. The line of totality passes over the equatorial portion of the Atlantic ocean, and reaches the west coast of Africa near Benguela, in latitude twelve degrees south. This port is easy of access, and as it is the healthy season, there would be no difficulty in sending a party out in a Government vessel. The duration of the totality at this point is four minutes and forty seconds, affording a more than usually good opportunity for photographic and spectroscopic observations. The question as to the propriety of applying for an appropriation to defray the expenses of an observing party has been referred by the Department to the National Academy and a report may soon be expected. Should it be favorable, I beg to recommend that a special application be made to Congress, as the funds ought to be available by February 1, 1886, at the latest.—*Report of Superintendent of Naval Observatory.*

The Naval Observatory drops time-balls daily at the following cities: Philadelphia, Baltimore, New Orleans, New York, Hampton Roads and Savannah.

EDITORIAL NOTES.

The MESSENGER will be sent hereafter to such subscribers only as indicate a wish for its continuance.

President EDWHRD S. HOLDEN is at his post of duty in the University of California. While his time at present is largely taken by the new responsibilities assumed, neither astronomy nor the MESSENGER will be long without his attention.

Of late much space has been given in this journal, to the physical appearance and the motions of the BIELA meteors, because so little is definitely known in this branch of astronomy. We trust the various papers will be read with interest.

DISCOVERY OF THE NEW BROOKS' COMET.—The mode in which WILLIAM R. BROOKS, of Phelps, New York, captured this prize from the skies, and $200 from Mr. WARNER for this discovery reads like a romance, especially since we later learned that Mr. BARNARD, of Nashville, Tenn. was also scanning the same part of the heavens, and on the following evening independently discovered the same comet. Mr. BROOKS' own words tell his part of the story well:

"At the time of my discovery of the comet in the early evening of December 26, 1885, it was low in the western heavens, and rapidly settling down into the tops of the trees of my orchard; indeed for some time the limbs of the trees were visible in the field of the telescope, occasionally hiding the comet entirely from view. I had already obtained its approximate position, but had not obtained its motion with sufficient certainty to telegraph the discovery that evening, as I was very anxious to do. So I removed the telescope from its permanent stand, carried it around the house into the front yard, facing the west. It was a big and heavy armful, for the tube of the large telescope is of iron and about a foot in diameter.

I then called to my wife and father to bring out a table, placed the upper end of the telescope across the front fence, and with boxes, doormats, books and papers placed upon the table, raised the instrument to the proper angle to point at the comet. While I stood in the road gazing anxiously into the telescope, my wife stood in the yard, holding and moving the telescope at my direction to follow the fast setting comet; while father placed books and papers upon the table to help support the instrument. In this way my last observations were made, and I was enabled to follow the comet until it almost touched the horizon. The message announcing the discovery was given to the telegraph office three quarters of a mile away before eight o'clock of the same evening."

Three important articles are deferred for want of space in this number.

THE DOUBLE-STAR H 2904.—After a careful examination of the measures of this pair, I am unable to agree with Mr. WILSON in his conclusion (S. M. January) that it is a binary system. By accurately plotting the measures on a large scale, it will be seen that its measured positions fall almost exactly on a right line—in fact, much more nearly so than is usnal where the motion is known to be rectilinear. The estimated positions of HERSCHEL are of no value in determining this question. The errors in his estimated distances will be found to be generally very large, the real distance being almost always in excess. If a line is drawn through the measured positions of the small star, the motion will be found to be in the direction of about 9°. In that case, HERSCHEL's estimate was less than half the real distance, an error by no means uncommon in his catalogues. This, however, would be materially lessened if the earlier measured distances were a little too large, or the later distances a little too small. In addition to this, it is, to say the least, very improbable that so wide a pair should prove to be a binary. I do not recall a single example of a recognized binary system where the components are so widely separated, I may add here that I made a series of measures of this pair at Madison in 1871, which are not given in Mr. WILSON's list. The apparent motion of the small star appears to be about 0.″4 per annum, in the direction, as stated, of 9°; and on the assumption the nearest approach of the two stars will be somewhere about 1910, when the distance should be about 13½″. Possibly on examination of some of the star catalogues would show whether or not the large star has any considerable proper motion. At all events, measures of the relative positions of the two stars for the next three or four years will be sufficient to determine the character of the movement. I have no doubt it will prove to be rectilinear.

Since writing the foregoing I have examined my star catalogues, and find that the star apparently corresponds to the following:—

B. A. C.	6814	O. Argelander 20054
Cape Catalogue	10699	Sag. 242 (Gould)
Lacaille	8262	Gould 1953 (Gen. Cat.)
Lalande	37813	Wash. Mu. C, Zones 138
Yarnall	8550	No. 27 (comp?)
		Mural C. Zone 170 No. 94.

It may be found in other catalogues which I have not access to at this time.

S. W. BURNHAM.

COMET (*e*) 1885 (BARNARD).

The following elements and ephemeris are by H. C. WILSON, assistant astronomer in the observatory of Cincinnati:

T — 1886 May 2.421 G. M. T.
$\pi - \Omega$ = 119° 52′ 16″
Ω = 68 30 03
i = 33 30 18
log q = 9.675168

The equations for the ephemeris are:

$x = r\,[9.581267] \sin (225° 53′ 38″ + v)$
$y = r\,[9.966313] \sin (232 35 35 + v)$
$z = r\,[9.999632] \sin (141 37 33 + v)$

Greenwich mean midnight	App. R. A.	App. Decl.	Log. Δ	Log. r	Light
Jan. 28	2h 21m 00.s2	+13° 31′ 28″	0.2217	0.2813	2.23
29	19 43. 6	44 20			
30	18 29. 6	57 18			
31	17 17. 7	14 10 22			
Feb. 1	16 08. 1	23 32	0.2256	0.2672	2.34
2	15 00. 7	36 47			
3	13 55. 6	50 08			
4	12 52. 6	15 03 35			
5	11 51. 7	17 07	0.2294	0.2523	2.46
6	10 52. 9	30 44			
7	09 56. 1	44 29			
8	09 01. 4	58 20			
9	08 08. 6	16 12 17	0.2328	0.2368	2.61
10	07 17. 8	26 20			
11	06 28. 9	40 29			
12	05 41. 8	54 45			
13	04 56. 5	17 09 08	0.2357	0.2206	2.77
14	04 12. 9	23 38			
15	03 31. 1	38 14			
16	02 50. 9	52 56			
17	02 12. 4	18 07 46	0.2379	0.2034	2.97
18	01 35. 4	22 42			
19	01 00. 0	37 46			
20	2 00 26. 1	52 57			
21	1 59 53. 7	19 08 17	0.2395	0.1854	3.20
22	59 22. 8	23 44			
23	58 53. 1	39 19			
24	58 24. 8	55 01			
25	57 57. 9	20 10 53	0.2402	0.1664	3.48
26	57 32. 4	26 52			
27	57 08. 2	42 59			
28	56 45. 3	59 14			
March 1	56 23. 9	+21 15 38	0.2402	0.1462	3.82

The light of the comet on December 3 is taken as unity A comparison of the ephemeris with an observation on Jan. 6 gave C−O = −1s.5, +3″

THE PLANET SATURN.—On the night of Jan. 6, 1886, I obtained a good view of *Saturn* with the 11-inch equatorial, and saw what I had never been able to see before, viz.: three narrow yellow bands on the southern hemisphere of the planet. These were seen only at moments of exceptionally good definition. There was also a faint dusky streak through the middle of the white equatorial belt. I could not see the narrow black belt on the southern edge of the equatorial belt, which has been spoken of by so many observers. There was, it is true, a narrow strip which appeared a little (a very little) darker than the other portions of the southern hemisphere, bnt I thought it was due to contrast with the whiteness of the adjacent equatorial belt.

The inner, dusky ring was very distinct and seemed a little broader on the following side. It seemed also to approach the planet closer on that side by an appreciable amount—I should say about 0."25. Otherwise the rings appeared symmetrical with reference to the planet. The magnifying powers employed were 230 and 450. H. C. WILSON.

LACAILLE 8262.—In Volume II, page 256, of SIDEREAL MESSENGER, Professor HOLDEN has given a number of places of the star *Lacaille* 8262, from various authorities which indicate strong proper motion. I had not noticed, last month, that this star is identical with the principal star of the double *h* 2904 (B. A. C. 6814).

If HERSCHEL's estimate of distance be assumed as about 20" too small, the whole change in the double may be due to the proper motion of the principal component. An error of 20" would be unusually large for HERSCHEL, but not impossible. The mean of his position angles is very nearly correct, assuming the proper motion $-0.^s009$ and $-0."53$ as given by Professor HOLDEN. Whether binary or not the star is worthy of numerous measures during the next half century. H. C. WILSON.

Meteors of 1885 Nov. 27:—Prof. N. R. LEONARD, observing with a number of assistants, on the evening of November 27, at Iowa City, Iowa made the following counts:

From $8^h\ 36^m$ to $8^h\ 51^m$, 100 meteors, or over 6 per minute. From $9^h\ 10^m$ to $9^h\ 30^m$, 100 meteors, or 5 per minute. From $10^h\ 2^m$ to $10^h\ 20^m$, 50 meteors, or less than 3 per minute, showing thus a rapid diminution. Clouds interfered with further observations. Prof. LEONARD states that Prof. COWGILL, who observed at Manhattan, Kansas, saw a meteor below the clouds (the sky being completely clouded over) at $12^h\ 50^m$, and during the few hours following, thirteen others were seen in like manner.

TUTTLE'S COMET.—This interesting periodic comet was seen at but two places, viz.: Nice, France, where it was first detected on the morning of August 9, 1882, and at the Warner Observatory on August 12. It was difficult of observation, in consequence of its rising so near the time of morning twilight as to leave an interval of but a few minutes wherein it would be possible to see it.

The next morning after receiving telegraphic notice of its discovery I set the telescope for it, but failed to find it, either in the field or in the immediate neighborhood. Feeling quite uncertain in catching the stranger I abandoned the search. But I had failed to see it in 1871, I was greatly chagrined at the thought of a similar disappointment now, so taking new courage I re-commenced the search and soon had the satisfaction of beholding it in the field, where I could hold it steadily. But, descending from the chair to start the driving clock for the obtaining of its approximate position, though returning in about ten seconds, I found that the increased twilight had entirely obliterated the comet which, by the test of this almost instant effacement, showed how exceedingly faint it must have been. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

DISAPPEARANCE OF THE NEW STAR IN THE ANDROMEDA NEBULA.—This wonderful star, whose appearance will always be remembered as an important astronomical event of the year just completed, may be said to have practically disappeared. On the evening of December 26, I obtained, by a desperate and long continued effort, what I very quickly became convinced would be my last view of it. With the dome-room perfectly dark, the pupil of the eye well expanded, the object near the zenith and the seeing good, I was able, with the 16-inch refractor to get only an occasional view of the star. Cloudy weather has since prevented any opportunity for examination, but the attempt to see it would, I think, now be a vain one, as the interim of twenty days would cause a decrease of brightness of, at least, another magnitude, which, even then, I estimated to be as low as the 16th or 17th.

The apparition of this star in the center of so conspicuous a nebula will long afford matter for reflection, and a theme for discussion by savans. It raises the question whether, after all, there is, even in the heavens, such a thing as stability. It has not, at any time, appeared red to me, from which I argue that it was not of the order of variables—popularly so called—but rather a temporary star, like that of Tycho and several others which have appeared in various parts of the heavens.

Of GORE'S new star I have been able to make one observation and find it decidedly red in tint—the color of nearly all variable stars—and hence I infer it to be a variable star of perhaps long period, and not a temporary one. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

SUSPECTED PROPER MOTION IN A NEBULA.—It is exceedingly doubtful if any evidence has been had of the detection of motion in any of the nebulæ. Such testimony astronomers hold in abeyance. In every case of supposed motion, investigation has shown that it was owing to mistaken entry, inaccurate observation or to error in position. But as motion of some sort, seems almost to be an attribute of matter as witnessed in the *Sun*, the planets and their satellites, the comet and stars also, it may, reasoning from analogy, be safely assumed that the nebulæ too have a motion, either axial or orbital, or more probably, of both kinds.

Nearly a year ago there appeared in several astronomical and scientific journals, a letter from Mr. H. SADDLER, of England, giving in detail. the reasons for supposing that the nebula, General Catalogue 2091, manifests proper motion, Dr. DREYER, in reply, contended that the circumstances, when carefully weighed, afford no evidence whatever of motion, and his conclusion appears to me to accord with the facts. I have been led to these reflections by another case of supposed motion which has come under my own observation. About a year since, while seeking for new nebulæ I ran across a very close double, so close indeed as to require a power of nearly 100 for its separation. Examination showed the nebula to be G. C. 2425=H. I. 247, discovered March 18, 1790 and registered as elongated. AUWERS in 1830 calls it very bright, pretty large, little elongated. Sir JOHN HERSCHEL in 1860 describes it as pretty bright, pretty small, very little elongated. It would seem, therefore, that none of these observers, all of whom used large telescopes and high powers, suspected duplicity, while now the components are very easily separated. If they have proper motion in opposite directions it is not unreasonable to conclude that in ninety-six years the separation ought to be noticeable. This nebula is in R. A. $11^h\ 22^m$, Dec. north $59^\circ\ 12'$. It should be watched and subjected to micrometrical measurements. LEWIS SWIFT.

WARNER OBSERVATORY, January 1886.

OCCULTATIONS AT THE CAPE OBSERVATORY.—Under date of November 13, 1885, Dr. GILL, Her Majesty's Astronomer at the Cape, writes that meridian observations of the *Moon* have been entirely discontinued at his observatory, and that the observations of occultations are now prosecuted with greater regularity than heretofore. He says: "I think it is only from such observations that very refined determinations of the *Moon's* place can be arrived at."

COMET PARIS. — This comet was observed December 2, and was found, contrary to the statement of the telegram, to be of moderate brightness. A small star was shining through the nebulosity when the telescope was first turned on it, but this was soon left behind by the rapid motion of the comet. E. E. BARNARD.

VANDERBILT UNIVERSITY OBSERVATORY, December 10, 1885.

OBSEVATIONS OF METEOR SHOWERS.—The following are additional observations of the radiant points, obtained here during the last two months:

Date			Radiant Point
1885 November	14	144° +50°	near Theta Ursæ Mrjoris.
	14	149 +21	Leonids.
	16	150 +22	Leonids.
	16	154 +41	near Mu Ursæ Majoris.
	17	166 +31	near Xi Ursæ Majoris.
	26	26 +44	Andromedes.
	27	24 +44	Andromedes.
	28	22 +43½	Andromedes.
	30	21 +42½	Andromedes.
	30	60 +49	near Mu Persei.
December	1	44 +56	near Eta Persei.
	1	194¾ +43	near Cor Caroli.
	4	79 +24	Zeta Taurids.
	4	105 +34	Geminids.
	4	110 +25	near Delta Geminorum.
	4	143 +48½	near Theta Ursæ Majoris.
	7	83 +19	near Eta Geminorum.
	7	115 +33	near Alpha Geminorum.
	9	161 +58	near Beta Ursæ Majoris.
	9	203 +57	near Zeta Ursæ Majoris.
	10	105 +50	in the Lynx.
	10	107 +33	Geminids.
	10	117 +32	near Alpha Geminorum.
	10	143 +39	in Leo Minor.
1886 January	2	228 +52	Quadrantids.
	2	119 +16	in Cancer south of Zeta.
	2	167 + 4	near Tau Leonis.
	5	140 +57	near Theta Ursæ Majoris.

I have only given the dates when the showers were best defined. I observed 566 shooting stars between November 14, 1885 and January 5, 1886, but I have omitted several thousands of Andromedes seen on the night of November 27.

W. F. DENNING.

BRISTOL, England, January 6, 1886,

Professor H. L. SMITH, of Hobart College, recently saw Gamma² *Andromedæ* clearly double with a 4¼-inch short focus telescope. Observers will rightly say that is a triumph for Professor SMITH's eye and telescope. We are not aware that this star has been separated by so small a telescope but once before. It is usually regarded a hard double for an aperture less than 8-inches. SCHIAPARELLI's measure in 1877 was P. A. 104.°1, distance 0.″48; GLEDHILL, same year, 102.°4; 0.″84; BURNHAM, in 1878, 102.°7; 0.″48.

It is possible, as STRUVE suggests, that the distance between the components is increasing, though these measures seem to show the contrary.

THE RED SPOT ON JUPITER.—With my 10-inch reflector, power 252, I have seen the red spot on seven occasions during the present apparition of *Jupiter*. The spot crossed the planet's central meridian at the following times:

1885 October	24	17h 32m
	26	19 10
December	1	19 0
	9	15 40
	28	16 21
1886 January	2	15 29
	4	17 6

This remarkable object is much more distinct than in 1883 or 1884, but is still far less striking than it was in 1879, 1880 or 1881.

The rotation period of *Jupiter*, as I have determined it from observations of the red spot during the preceding three oppositions is as follows:

Date of limiting observations.	No. of rotations.	Period of rotation.
1882 July 29—1883 May 4	674	9h 55m 39.s1
1883 Aug. 23—1884 June 12	710	9 55 39. 1
1884 Sept. 21—1885 July 8	700	9 55 39. 2

The three results are almost perfectly coincident and prove that the motion of the spot has been very equable since the summer of 1882. Before that time it exhibited a slackening velocity which originated a constantly increasing rotation period.+When the spot became very faint in 1882, this retardarion appears to have ceased. W. F. DENNING.

BRISTOL, England, January 6, 1886.

The Paris comet (Fabry) will be pretty bright after perihelion. I have computed the following ephemeris from CHANDLER and WENDELL'S elements (Sci. Obs. Circular No. 62) which seem to be more accurate than those given in Dun Echt Circular No. 102:

COMET "FABRY."

	R. A.	Decl.	Log. r	Log. Δ	Light
Jan. 4	23h 40.m6	+21° 03′	0.1839	0.1282	1.7
Feb. 3	23 22. 2	+24 37	0.0093	0.1036	4.3
Mar. 5	22 57. 2	+27 28	9.7383	9.9440	31.6
15	22 38. 3	+10 50	9.6905	9.8357	64.9
25	22 42. 0	− 0 05	9.7383	9.7397	81.0
Apr. 4	23 08. 2	−25 18	9.8343	9.7398	52.0

H. C. WILSON.

BOOK NOTICES.

The Moon: Considered as a Planet, a World and a Satellite. By JAS. NASMYTH and JAS. CARPENTER. New York: SCRIBNER and WELFORD, 1885: $7.50: 8vo.

A royal volume this is, and one which will loosen the purse strings of many a lover of astronomy. The work has been out of print for some time, having been published in 1874, and the demand for it has brought out this, the third edition, which is less unwieldy than the former editions (which were quartos), and less costly. As there are few copies of the original work in this country, it may be well to describe it quite fully. The book is the product of thirty years of assiduous observation, with power-

ful telescopes. After numerous drawings of a given object had been made at times when it was most favorably seen, and these drawings had been severely scrutinized, revised and compared with the *Moon's* surface, a model was made. This, being set in the sunlight to show the lunar effects of light and shadow, was photographed. Thus a "highly satisfactory" representation was obtained. Most of the twenty-five magnificent full page plates (Woodbury types) scattered throughout the volume show different portions of the *Moon's* surface as viewed with a high magnifying power. Thus our satellite is brought to the fireside of the beholder. In the first three chapters an exposition of the phenomena attendant upon the cooling of a nebulous mass is given. After a solid crust had been formed, the molten interior is supposed to have expanded, rupturing the crust, and escaping: after the eruptive action died away, in the subsequent process of cooling the crust was wrinkled into mountain chains. The authors believe that most of the irregularities of the lunar surface can be accounted for by the alternate expansion and contraction of successive strata.

Chapters IV and VI treat of the form, magnitude, weight and general appearance of the lunar globe, while chapter V is devoted to its atmosphere. Chapter VII is devoted to topography, a map being given with the names of two hundred and twenty nine craters. The next five chapters are occupied with the discussion of the method of formation of each *class* of the lunar features. In the chapter on the *Moon* as a World, the reader is transported to the crater Copernicus, and remains for a lunar day, his experiences being vividly depicted. The services of our satellite to earth-dwellers are set forth next, and the volume closes with a resume of its own contents. By reason of the vivacity of its style and the sumptuousness, as well as accuracy of its illustrations, this work must be preferred to NEISON'S, by all except professed selenographers. It ought to have a large sale.

Doolittle C. L. A Treatise on Practical Astronomy as Applied to Geodesy and Navigation. New York, WILEY, pp. 642, 8vo.

This work is intended for students in Universities and Technical Schools, and as a manual for the field astronomer: the portion which bears upon Navigation is the fifty-page chapter on the sextant and its use in determining time and latitude. As an Introduction we find a chapter on Least Squares, and one on Interpolation. In Least Squares the author presupposes only such knowledge of the theory of probabilities as can be found in most treatises on Higher Algebra, and carries the reader by comparatively easy steps up to the integration of the well known gamma function, after which he discusses probable error, mean

error, etc., and concludes by elaborating the method of solving normal equations. The criteria of PIERCE and others for rejection of doubtful observations are simply mentioned. This chapter is so lucid that it is delightful reading to one at all interested in the subject.

The treatise on Practical Astronomy proper begins at page 100 and the instruments treated of are the sextant, chronometer, clock, chronograph, portable transit, zenith telescope and theodolite. The various uses of these instruments are explained with fulness and clearness, and illustrated by a large number of examples fully solved: most of these examples have been taken from the reports of government surveys, while quite a number come from the author's own observations at the Sayre observatory. No antiquated instruments or methods are touched upon, it being the author's design to furnish a view of the best modern practice. In connection with the transit, the construction, and mathematical theory, use of HARKNESS'S spherometer-caliper are explained. The following subjects are also treated: the Celestial Sphere, Parallax, Refraction, Time, Latitude, Longitude, Precession, Nutation, Aberration and Proper Motion. In the difficult subject of Refraction, no attempt is made to follow BESSEL'S investigation, but DESCARTES' Laws are stated, and the use of the tables is explained.

Considerable care has been taken to have all formulæ printed correctly, and in a three hours' examination the present writer noticed nothing wrong, except the omission of a half-parenthesis in line five of page 145. At the end of the book are a few tables, chiefly for refraction and the reduction of circum-meridian altitudes to the meridian: these are printed in vexatiously small type.

Special mention should be made of the fact that the author's style is lucid, and in almost every instance the reader may see at once how any particular equation is derived: this makes the perusal of the work a pleasure rather than a task. On the whole the book is to be highly commended, since it fills the niche for which it is intended admirably.

H. A. H.

PAPERS RECEIVED.

1. On the effect upon the *Earth's* velocity produced by small bodies passing near the *Earth*. By Professor H. A. NEWTON.
2. Colored media for the photographic dark room. By Professor W. H. PICKERING.
3. Methods of determining the speed of photographic exposures. By Professor W. H. PICKERING.
4. The fixed idea of astronomical theory. By AUGUST TISCHNER.
5. The intimate connection between gravitation and the solar parallax. THOMAS BASSNETT.
6. Velocity of light in air and refracting media. By Professor SIMON NEWCOMB.

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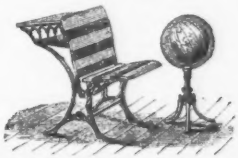

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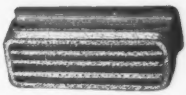

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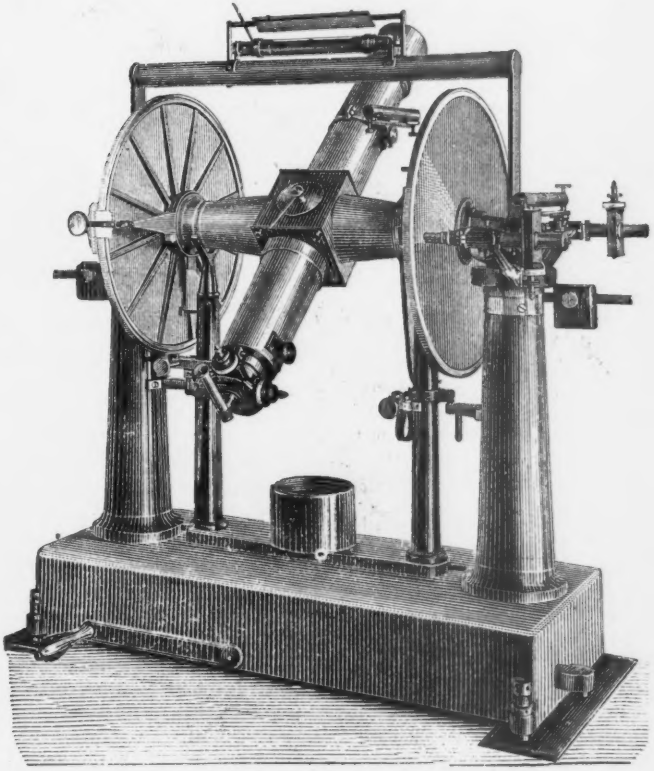

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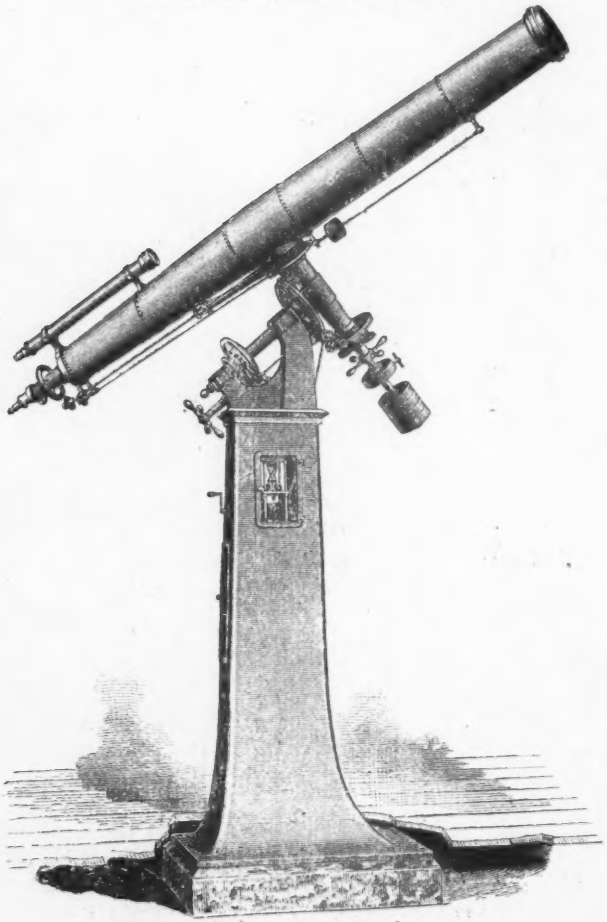

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